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AUTHOR: (8) Getmantsev, G.G.

TITLE: (6) On the heating of interstellar gas by cosmic rays

PERIODICAL: (15) Astronomicheskiy zhurnal, v.39, no.5, 1962, pp. 856-861

TEXT: It is argued that the heating of interstellar gas due to ionization losses can only be effective at relatively high temperatures of the medium and can hardly be responsible for an increase in the temperature if the initial temperature is much less than 10^4 deg. This paper is concerned with a second possible mechanism which is effective provided the temperature is not too high. It is assumed that a cosmic-ray stream moves along randomly oriented magnetic lines of force. Owing to the high conductivity of the interstellar gas, the magnetic field due to the cosmic-ray stream cannot be produced in a short interval of time and the stream is almost completely compensated by electron currents in the interstellar plasma. The gas should then become heated owing to Joule losses. It is shown that these losses are given by $W_2^* = 3\ mc^2N^2/T^{3/2}$, where N is the cosmic-ray density, T is the temperature and m is the mass of the cosmic-

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ray particles. In deriving this expression it is assumed that the particle velocity is $v_2 = c/3$ and the conductivity of the interstellar gas is $\sigma \sim e^2T^{3/2}/27\ m$. These losses are then shown to be greater than the rate of emission of energy through recombinational processes so that the temperature of the gas should increase and this increase will continue until the two effects just balance each other. Detailed examination of this type of effect leads to the conclusion that cosmic rays cannot in fact ensure any appreciable heating of interstellar gas in those regions of the galaxy where the gas concentration is large ($n \sim 0.1$-$1\ cm^{-3}$) unless it is assumed that there are cosmic rays with $E/mc^2 \sim 0.1$-0.01 and $N \sim 10^{-4} - 10^{-5}\ cm^{-3}$. If, on the other hand, the gas density in the halo is of the order of 10^{-3} - $5 \times 10^{-4}\ cm^{-3}$ or if there are regions in which the concentration is of this magnitude, then primary cosmic rays might be able to heat the gas. If these conditions are satisfied and if the sources of cosmic rays ensure that the concentration of cosmic electrons with energies of $10^4 - 10^5$ eV is of the order of $3 \times 10^{-8}\ cm^{-3}$, then an interstellar medium with $n \sim 10^{-3}$-$5 \times 10^{-4}\ cm^{-3}$

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may become heated to a limiting temperature of a few million deg. If in addition the initial temperature is low, then in the initial stage of the heating process the latter should be due to the "induction" mechanism mentioned above and the temperature should rise to about 10^5 deg in a time interval of the order of 10^{12}-10^{13} sec.

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